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Study into improving effects of plant residues on soil properties and performance of white seed melon (*Cucumeropsis mannii* Naudin)

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Abstract

Field experiment to determine the effect of crop residues and NPK fertilizer (NPKF) on soil properties and growth of white seed melon was carried out at kabba and Ile-Oluji in Kogi and Ondo States of Nigeria. It involved application of cocoa bean husk (CBH), cocoa pod husk (CPH), coca pod waste (CPW), weed much (WM), NPK 15:15:15 Fertilizer (NPKF) and control (no treatment) given a total of seven soil treatments. All the amendments tested significantly improved growth components of white seed melon, soil physical and chemical properties at both locations after harvest relative to control. 300 kg/ha NPKF gave highest number of leaves, number of branches, vine length, leaf length and width of white seed melon at both locations. Highest and least values of moisture content and porosity were obtained for soil treated with 6 t/ha CBH and 300 kg/ha NPKF respectively while least and highest values of bulk density and temperature were observed in soil treated with 6 t/ha CBH and 300 kg/ha NPKF respectively among the amendments tested. Highest value of pH, organic matter (OM), available P, exchangeable k, Ca, Na and Mg, ECEC and base saturation were recorded for soil treated with 6 t/ha CBH after harvest. 6 t/ha CBH is recommended for sustainable soil improvement and production of white seed melon in the study area.

1. INTRODUCTION

Mann's cucumeropsis (*Cucumeropsis mannii* Naudin*)* is a member of the Cucurbitaceae family, a species of melon native to tropical Africa where it is grown for food and as a source of oil. Its common names include egusi-itoo and white seed melon [1]. This crop is often referred to as “the real egusi” given its long history in West Africa, dating back 4,000 years [2]. This crop is primarily harvested for its large white seeds called egusi-itoo. The seeds are commonly processed into soups and oil products, and are also eaten individually as a snack [3].

Benefits of *Cucumeropsis mannii* are many. Kernel of the crop holds significant nutritional value. Oil makes up 44% of the seed, where 30% is protein rich in essential amino acids, 10% carbohydrate, 4% ash and 3% fiber [3]. The seed is an excellent vegetable protein, and is ideal for battling nutritional debilitations. It is high in essential vitamins and minerals, egusi-itoo compliments the starch and grain diet of most Africans [3]. The seed contains every important macro and micro-nutrient in quantities ideal for nutrition [4]. The amino acid content of egusi-itoo proteins makes it a sufficient vegetable protein. This composition is ideal for sick and growing bodies, providing essential amino acids and calories [3]. Just 100 g of seed daily provides essential fatty acid, amino acid and Vitamin E requirements [4]. There is potential for these seeds as a critical tool for interventions in diseases such as marasmus and kwashiorkor [3]. The seeds are prepared for consumption by parching and pounding to free the kernels of the seedcoat. The kernels are milled into a whitish paste which is used in soups and stews. The seeds (including seedcoat) are also roasted and served as a snack. They resemble groundnut in flavour.

Despite the crops obvious advantages, *Cucumeropsis mannii* remains an underutilized tool for nutritional intervention in over the last 50 years due to soil fertility challenge. [3] reported that a complete fertilizer should be applied before the propagation of *Cucumeropsis mannii* with periodical application of nitrogenous fertilizer. Growing of *Cucumeropsis mannii* in savannahs with low fertility and organic matter was reported to be more challenging [3]. Synthetic fertilizers have become the primary nutrient source for agriculture, it ensures quick availability of nutrients to crops they have limited residual effect of the applied nutrients [5]. Recent experience in Nigeria agriculture shows that the use of inorganic fertilizers to achieve high crop yield is unsustainable due to its scarcity and high cost [6]. Inorganic fertilizer has not been helpful in intensive agriculture because it is often associated with reduction in crop yield, soil acidity, nutrient imbalance, leaching, erosion, volatilization and degradation of soil physical attributes [6]. Impacts of chemical fertilizer on the environment had also raised serious public concern; leaching of nitrates and phosphates from soil is problematic, and fertilizers have been linked to marine eutrophication and groundwater contamination [7]. Organic fertilizers are known to be slow released nutrient sources. This implies that crops can suffer initial starvation from nutrient immobilization prior to mineralization. They are also required in large quantities which may not be readily available to farmers [8, 5, 9]. Organic fertilizer can be used to improved soil characteristics and obtain high crop yields in addition with inorganic fertilizer [10]. The addition of organic amendments to manage the current trend of soil physical, chemical and biological degradation has been recommended by [11]. [12, 13] recognized the need to intensify studies into locally sourced, cheap, adoptable organic sources of plant nutrients. For these reasons recent research has focused on seeking effective sustainable and organic alternatives to enhance soil fertility and crop yields.

2. MATERIALS AND METHODS

The study was conducted during 2018 cropping season at the Teaching and Research Farms of Federal Polytechnic Ile Oluji, Ondo State and ABU College of Agriculture, Kabba, Kogi State. Ile Oluji is located in the rainforest Zone of Nigeria on latitude 6.04^0 E and longitude 7.50^0 N and altitude of 427 metres with average rainfall of 130 cm and mean annual temperature between 28.8 ^{0}C to 35 ^{0}C. The annual relative humidity is 81.2 percent. Kabba is located in the Southern Guinea savanna Agro - Ecological Zone of Nigeria on latitude 7^0 50' N and longitude of 6^0 03'E and altitude of 427 metres with average rainfall of 130 millimetres and mean annual temperature between 28.8 ^{0}C to 35 ^{0}C. The annual relative humidity is 81.2 percent.

2.1 Experimental design and treatments

The experiment was arranged in a randomized complete block with each treatment replicated four times. The area used was 24 m x 51 m (1224 m^2) in total. Each plot measured 4 m x 3 m with discard of 1m within the plots and 2 m between the block. The trial involved six treatments of cocoa bean husk (CBH); cocoa pod husk (CPH); cocoa pod waste (CPW); Kola pod husk (KPH) at 6 t/ha each, 4 t/ha weed mulch (WM) (*Tithonia diversifolia*), 300 kg/ha NPK 15:15:15 fertilizer (NPKF) and control (no amendment). Two seeds of white seeds melon were planted per hole and later thinned to one at a spacing of 1 m x 1 m with a total of twenty (20) plants per plot

Prior to commencement of experiment, soil samples randomly collected from 0 – 20 cm depth were thoroughly mixed to form a composite which was later analyzed for physical and chemical properties. At the harvest, another set of composite samples were collected per plot basis and similarly analyzed for routine chemical analysis as described by Carter (1993). The soil samples were air-dried and sieved using a 2 mm sieve before making the determinations. Soil organic matter was determined by the procedure of Walkley and Black using the dichromate wet oxidation method [14], total N was determined by micro-Kjeldahl digestion method [15], available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry [16]. Exchangeable K, Ca and Mg were extracted using 1.0 N ammonium acetate. Thereafter, K was determined using a flame photometer and Ca and Mg were determined by EDTA titration method [17]. Soil pH was determined in soil water (1:2) medium using the digital electronic pH meter. Particle size analysis was done using Bouyoucos hydrometer method [18]. Soil bulk density was determined using the core method [19].

2.2 Data collection and statistical analysis

Five plants of white seed melon were randomly selected from each plot across the three blocks for growth determination. The parameters assessed included number of leaves, number of branches, vine length, leaf length and leaf width.

The data collected were subjected to analysis of variance (ANOVA) using the SPSS package (version 16) and treatment means were compared using the Duncan's multiple range test (DMRT).

3. RESULTS AND DISCUSSIONS

3.1 Pre-Planting Soil properties

Table 1 shows soil properties of the experimental sites at Kabba and Ile Oluji Nigeria prior to planting. The values of soil Bulk density were (1.45 and 1.38 g/cm^3), Porosity (43.2 and 42.4%), Soil temperature 36.1 and Soil moisture 6.31%. The result revealed that the soil at the locations were sandy loam, acidic, low in N, available P, exchangeable K and OM in accordance with the rating of [20]. Therefore, the results revealed that additional soil conditioner would be needed before the soil could effectively produce crop.

Table 1: Pre-Planting Soil properties

Property	Kabba	Ile – Oluji
Sand (%)	77.6	73.9
Silt (%)	11.9	14.7
Clay (%)	10.5	11.4
Textural Class	Sandy loam	Sandy loam
Bulk density g/cm^3	1.45	1.38
Total porosity (%)	43.2	42.4
pH (H_20)	5.61	5.83
Organic Matter (%)	2.28	2.36
Total N (gkg^{-1})	0.17	0.20
Available P (mgkg^{-1})	13.41	15.14
Exchangeable K (cmolkg^{-1})	0.14	0.17
Exchangeable Ca (cmolkg^{-1})	2.13	2.61
Exchangeable Mg (cmolkg^{-1})	1.14	1.24
Na (cmolkg^{-1})	0.52	0.58
H (cmolkg^{-1})	1.37	1.29
Al (cmolkg^{-1})	0.75	0.81
ECEC	6.05	6.7
BS (%)	65.0	59.31

BS = Base saturation

Table 2 presents results on effects of amendment on growth components of white seed melon, observation revealed that application of 300 kg/ha. NPKF, 6 t/ha CBH, 6 t/ha CPH, 6 t/ha CPW, 6 t/ha KPH and 4 t/ha WM increased number of leaves, number of branches, vine length, leaf length and width of white seed melon relative to control. 300 kg/ha NPKF gave highest number of leaves, number of branches, vine length, leaf length and width of white seed melon at both locations although it showed no significant difference with plants treated with 6 t/ha (CPW, CBH and CPH) on number of branches, leaf length and width at both locations. Plants treated with 6 t/ha KPH and 4 t/ha WM respectively obtained least values of number of leaf, number of branches, vine length, leaf length and width of white seed melon among the plant residues but significantly $P < 0.05$ higher than the values obtained for the control.

Soil physical properties as influenced by soil amendments are presented in table 3. All the amendments tested significantly improved soil physical properties relative to control. Highest values of soil moisture content and porosity and least values of bulk density and temperature were obtained for soil treated with 6 t/ha CBH, 6 t/ha CPH, 6 t/ha CPW, 6 t/ha KPH, 4 t/ha KPH and 300 kg/ha NPKF respectively. Plant treated with 300 kg/ha NPKF recorded the least values of moisture content and porosity among the amendments but significantly higher than the control at $P < 0.05$.

Table 2: Effect of amendments on growth components of white seed melon

Treatment	Number of Leaves		Number of branches		Vine length (cm)		Leaf length (cm)		Leaf width (cm)	
	Kabba	Ile-Oluji	Kabba	Ile-Oluji	Kabba	Ile-Oluji	Kabba	Ile-Oluji	Kabba	Ile-Oluji
Control	210f	213.47f	10.04c	7.70d	286.37g	287.20g	13.70c	14.83c	18.57b	18.10c
300 kg/ha NPKF	273.57a	274a	12.03a	11.27a	842.80a	844.30a	17.13a	18.57a	22.50a	23.47ab
6 t/ha CBH	271.3c	272.57b	12.00a	11.21a	834.23c	835.60c	16.77ab	18.53a	22.13a	23.17ab
6 t/ha CPH	268.87d	269.17c	11.97a	11.20a	808.77e	810.20e	16.47ab	18.10ab	22.23a	23.13ab
6 t/ha CPW	272.65b	273.97a	12.01a	11.22a	839.13b	842.67b	16.90a	18.03ab	22.40a	23.63a
6 t/ha KPH	268.27d	268.48d	11.57ab	10.80b	815.93d	817.57d	16.40ab	17.83ab	22.10a	23.00b
4 t/ha WM	265.03e	265.33e	11.20b	10.40c	772.90f	770.70f	16.07b	17.50b	22.47a	23.43ab

Data followed by the same alphabet along the columns are not significantly different at P = 0.05 using Duncan's Multiple Range Test (DMRT). CBH = Cocoa Bean Husk CPH = Cocoa Pod Husk, CPW = Cocoa Pod Waste, KPH = Kola Pod Husk, WM = Weed Mulch, NPKF = NPK 15:15:15 Fertilizer

Table 3: Effect of amendments on soil physical properties

Treatment	Moisture (%)		Porosity (%)		Bulk density (g/cm^3)		Temperature (^0C)	
	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji
Control	6.07e	5.46d	32.40g	31.66g	1.30a	1.40a	34.3a	33.6a
300kg/ha NPKF	6.11e	5.68d	36.80f	35.98f	1.28b	1.30b	31.7b	30.3b
6 t/ha CBH	9.67a	8.84ab	51.80a	51.14a	1.08f	1.10f	27.6de	26.9d
6 t/ha CPH	9.53ab	9.26a	48.70b	46.90b	1.09e	1.14d	28.0d	27.4d
6 t/ha CPW	8.97cb	8.62b	46.20c	42.81d	1.09e	1.12e	27.4ed	26.2e
6 t/ha KPH	8.74c	8.65ab	44.70d	45.88c	1.10d	1.16c	29.7c	29.1c
4 t/ha WM	7.97d	7.85c	40.10e	39.64e	1.11c	1.15cd	27.2e	25.8e

Data followed by the same alphabet along the columns are not significantly different at P = 0.05 using Duncan's Multiple Range Test (DMRT). CBH = Cocoa Bean Husk CPH = Cocoa Pod Husk, CPW = Cocoa Pod Waste, KPH = Kola Pod Husk, WM = Weed Mulch, NPKF = NPK 15:15:15 Fertilizer

Table 4 presents data on effect of amendments on soil pH, OM, N, and P. The results revealed that application of amendments improved significantly soil pH at both locations relative to control. pH values obtained for soil treated with 6 t/ha (CBH, CPW, CPH and KPH) were not significantly different from one another but significantly higher than the pH value recorded for soil treated with 300 kg/ha NPKF. The values of OM recorded for the plant treated with 6 t/ha (CBH, CPW KPH and WM) were significantly higher than the value of OM obtained for 300 kg/ha NPKF and control. Highest value of soil N, and P were recorded for soil treated with 6 t/ha CBH, N value obtained for 300 kg/ha NPKF was not significantly different from recorded for 6 t/ha CPW, 6 t/ha CPH at both locations. Value of P recorded for 300 kg/ha NPKF was significantly lower than that of 6 t/ha CBH but showed no significant difference compared with 6 t/ha CPW at Kabba.

Table 4: Effect of amendments on soil pH, OM, N and P after harvest

Treatment	pH		OM (%		N (%)		P (%)	
	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji
Control	5.20c	5.06d	1.97f	1.85g	0.27e	0.20f	8.41e	7.88e
300 kg/ha NPKF	5.72b	5.41c	2.30e	2.14f	0.71b	0.65c	21.08c	20.87c
6 t/ha CBH	6.83a	6.66a	5.16a	4.97a	0.86a	0.85a	23.02a	22.78a
6 t/ha CPH	6.76a	6.41b	5.09b	4.76c	0.71b	0.65c	22.70b	22.65b
6 t/ha CPW	6.69a	6.62a	5.11b	4.93b	0.71b	0.81b	21.25c	20.10d
6 t/ha KPH	6.74a	6.41b	4.81c	4.66d	0.69c	0.58d	21.08c	20.87c
4 t/ha WM	6.13b	6.06c	3.65d	3.18e	0.69c	0.55e	20.19d	20.07d

Data followed by the same alphabet along the columns are not significantly different at P = 0.05 using Duncan's Multiple Range Test (DMRT). CBH = Cocoa Bean Husk CPH = Cocoa Pod Husk, CPW = Cocoa Pod Waste, KPH = Kola Pod Husk, WM = Weed Mulch, NPKF = NPK 15:15:15 Fertilizer

Table 5 presents data on effects of amendments on soil exchangeable bases, acidity, ECEC, and base saturation after harvest. The result revealed that all the amendments tested significantly increased soil properties relative to control at both locations. 6 t/ha CBH got highest value of Ca, Mg, Na, K, ECEC and base saturation and reduced H and Al concentration among the amendments and it was significantly different. 4 t/ha WM had the least concentration of Ca, Mg, Na, K, ECEC and percent base saturation and it was significantly lower than the value obtained for 300 kg/ha NPKF.

Table 5: Effect of soil amendments on Exchangeable Bases, Acidity, ECEC and Base Saturation after harvest

Treatment	Ca Cmol/kg		Mg Cmol/kg		Na Cmol/kg		K Cmol/kg		H^+ Cmol/kg		Al Cmol/kg		ECEC Cmol/kg		BS (%)	
	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji	Kabba	Ile Oluji
Control	1.61g	1.42f	0.40f	0.37g	0.61g	0.69c	0.47d	0.41f	2.07a	1.97a	0.80a	0.75a	5.83c	5.52c	52.52f	50.44g
300 kg/ha NPKF	1.73d	1.68c	0.51e	0.46f	0.74e	0.67d	0.84b	0.75c	1.94b	1.82b	0.73b	0.71b	6.49ab	6.09b	58.86e	58.48f
6 t/ha CBH	1.82a	1.78a	0.93a	0.88a	0.83a	0.77a	0.92a	0.86a	1.64f	1.56e	0.27g	0.23g	6.41ab	6.08b	70.20a	70.56a
6 t/ha CPH	1.75c	1.68c	0.83c	0.78c	0.81b	0.78a	0.86b	0.83b	1.67e	1.65d	0.28f	0.32e	6.35ab	6.25a	69.29b	68.32b
6 t/ha CPW	1.80b	1.72b	0.91b	0.86b	0.79c	0.71b	0.82b	0.72d	1.67e	1.56e	0.30e	0.34d	6.40ab	5.73abc	68.20c	65.62d
6 t/ha KPH	1.72e	1.52e	0.82c	0.76d	0.78d	0.71b	0.81b	0.58e	1.73c	1.66d	0.32d	0.26f	6.21ab	5.85ab	69.90b	67.35c
4 t/ha WM	1.68f	1.64d	0.71d	0.67e	0.69f	0.63e	0.66c	0.58e	1.69d	1.67c	0.45c	0.41c	5.86cb	5.52cb	63.82d	64.31e

Data followed by the same alphabet along the columns are not significantly different at P = 0.05 using Duncan's Multiple Range Test (DMRT). CBH = Cocoa Bean Husk CPH = Cocoa Pod Husk, CPW = Cocoa Pod Waste, KPH = Kola Pod Husk, WM = Weed Mulch, NPKF = NPK 15:15:15 Fertilizer

This work demonstrated the importance of plant residues as organic amendment in enhancing crop productivity in poor and nutrient depleted tropical soils. All the amendments tested improved soil nutrient concentration and growth performance of white seed melon. 300 kg/ha NPKF significantly increased all the growth components of white seed melon but had relatively lower concentration of N, P, K, Ca, Mg, ECEC and base saturation after harvest. The increase in growth parameters could be as a result of NPKF ability to quickly release its nutrients for plant use before mineralization of plant residues by microorganisms [21]. Higher concentration of N, P, K, Ca, Mg, ECEC and base saturation recoded for soil treated with 6 t/ha CBH, 6 t/ha CPW, and 6 t/ha CPH after harvest could be adduced to their gradual release of nutrients immobilized in the plant residues compared with chemical fertilizer which could lose all its remaining unused plant nutrients due to volatilization, leaching and erosion. The improved soil physical condition by plant residues enhanced reduction in soil compaction and made easier the penetration of plant roots which facilitated uptake of more nutrients. The increase in soil organic matter caused by application of plant residues is adduced to have improved soil porosity, moisture content and low bulk density and temperature experienced in soil. Studies carried out in south western Nigeria [22, 23, 24] showed that cultivation with use of organic materials did not only give comparable yields in arable crops but higher soil quality was also recorded. It has also proved effective in improvement of sandy soil structure, water holding capacity and nutrient retention [24]

4. CONCLUSION

Plant and crop residues such as cocoa bean husk, cocoa pod husk, kola pod husk, cocoa pod waste and weed mulch are effective and reliable sources of plant nutrients particularly for white seed melon because their application to the soil enhanced soil nutrients concentration, soil physical condition and growth components of white seed melon. It is therefore recommended that 6 t/ha CBH, 6 t/ha CPW and 6 t/ha CPH applied as fertilizer materials for improving soil nutrient condition and ensuring sustainable production of white seed melon. This recommendation is important because of their ability to stay longer than mineral fertilizers that are volatile and leach easily.

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CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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